PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-150754
(43)Date of publication of application : 02.06.1998

(51)Int.Cl. H02K 19/10
H02K 1/27

(21)Application number : 08-307963
(22)Date of filing : 19.11.1996

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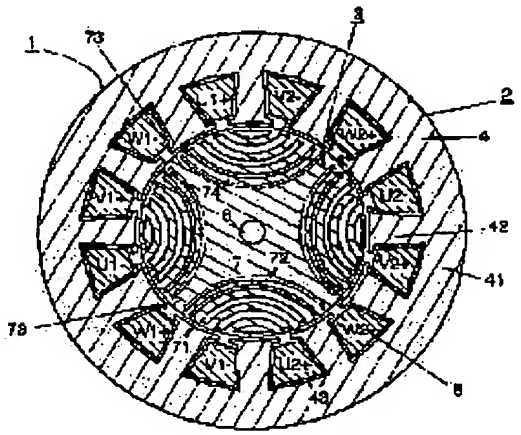
(54) RELUCTANCE MOTOR AND MOTOR VEHICLE EMPLOYING IT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a small, lightweight and highly efficient reluctance motor.
SOLUTION: The reluctance motor 1 comprises a rotor 3 arranged with poles substantially at constant intervals, and a stator 2 including core teeth 42 applied with a stator winding 5 and a stator yoke section 41 constituting the flux channel of each pole. The rotor 3 has a plurality of slits 72 made from one pole toward an adjacent pole wherein the slit 72 has a large width on the air gap side and a small width on the opposite side.



LEGAL STATUS

[Date of request for examination]	04.07.2000
[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3286542
[Date of registration]	08.03.2002
[Number of appeal against examiner's decision of rejection]	

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CLAIMS

[Claim(s)]
[Claim 1] It is the reluctance motor characterized by having had two or more slits in which said rotator was formed toward said adjoining magnetic pole in the reluctance motor equipped with the stator containing the rotator which has each magnetic pole at equal intervals mostly, the iron core tooth part around which the stator winding was wound, and the stator York section which constitutes the magnetic-flux passage of each of said magnetic pole from said one magnetic pole, and having been large and making width of face of this slit small by the anti-opening side by the opening side.
[Claim 2] It is the reluctance motor characterized by said slit carrying out insertion maintenance of the permanent magnet in claim 1.
[Claim 3] In a reluctance motor equipped with the stator containing the rotator which has each magnetic pole at equal intervals mostly, the iron core tooth part around which the stator winding was wound, and the stator York section which constitutes the magnetic-flux passage of each of said magnetic pole While said rotator has two or more slits and periphery bridge which were formed toward said adjoining magnetic pole from said one magnetic pole, and two or more bridges It is the configuration which has said magnetic pole core which consists of the magnetic substance focusing on a magnetic pole, and connected the opening side of said bridge and said magnetic pole core by the part of said periphery bridge. The reluctance motor characterized by the radial width of face S1 and S2 of said periphery bridge and S3 .... being larger than Maximum Sm, and carrying out hoop direction width of face St by the side of the opening of said magnetic pole core.
[Claim 4] It is the reluctance motor characterized by having two or more slits in which said rotator was formed toward said adjoining magnetic pole in the reluctance motor equipped with the stator containing the rotator which has each magnetic pole at equal intervals mostly, the iron core tooth part around which the stator winding was wound, and the stator York section which constitutes the magnetic-flux passage of each of said magnetic pole from said one magnetic pole, and making the configuration of this slit unsymmetrical to a hand of cut.
[Claim 5] The reluctance motor characterized by having been small in the width of face of the hand of cut of said slit, and enlarging width of face of an anti-hand of cut in claim 4.
[Claim 6] The electric car characterized by using the reluctance motor of claim 1, claim 3, or claim 4 given in any 1 term.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the electric car which used a reluctance motor and it.
[0002]
[Description of the Prior Art] A thing efficient lightweight [small] as a motor used for an electric car is desired. A miniaturization can be attained by carrying out high-speed rotation of the motor. As a drive motor of electric cars, such as an electric vehicle and a dc-battery fork, the brushless motor which used the permanent magnet type for the 1st, and used reluctance for the 2nd is the more nearly optimal than the above point. Especially a reluctance motor has the good point that it is almost equivalent to a ferrite magnet, and there are no problems, such as the temperature dependence of a property and magnetic demagnetization, although effectiveness, torque, etc. fall as compared with the magnet motor using an aperiodic compass, and has the advantage that a price is cheap and it is still more practical.
[0003] And as a conventional technique, it is indicated in the 96 or Institute of Electrical Engineers of Japan' June issue "the field analysis of the flux barrier mold reluctance motor using a slit rotator, and a prototype experiment." the structure which carries out the laminating of the magnetic substance, such as silicon steel, for a rotator to shaft orientations with the above-mentioned technique -- it is -- and the core of one magnetic pole (or called a salient pole) of a rotator -- since -- the structure of preparing a how many layer thing nonmagnetic slit toward the core of a magnetic pole is indicated. magnetic pole core which serves as most important factor with a reluctance motor according to such structure (or called a salient pole core) the ratio of reluctance (Xd) and the reluctance (Xq) between magnetic poles (or called between salient poles) -- it is large in Xd/Xq, that is, it is indicated that generating torque of a motor can be enlarged.
[0004]
[Problem(s) to be Solved by the Invention] however -- the above-mentioned conventional technique -- the ratio of the reluctance based on magnetic poles (Xd), and the reluctance between magnetic poles (Xq) -- although it became large when Xd/Xq was compared with the common reluctance motor, a technical problem is in improvement in the mechanical strength at the time of high-speed operation in the case of it being still inadequate, and improving further, and using it as a driving motor for electric vehicles.
[0005] Therefore, the purpose of this invention is to cancel the above-mentioned technical problem and offer the electric car using a reluctance motor and it lightweight small and efficient.
[0006]
[Means for Solving the Problem] The description of a reluctance motor of attaining the above-mentioned purpose In a reluctance motor equipped with the stator containing the rotator which has each magnetic pole at equal intervals mostly, the iron core tooth part around which the stator winding was wound, and the stator York section which constitutes the magnetic-flux passage of each of said magnetic pole Said rotator is for it to have been large and have made [had two or more slits formed toward said adjoining magnetic pole from said one magnetic pole, and] width of face of this slit small by the anti-opening side by the opening side.
[0007] Moreover, while having two or more slits and periphery bridge which were formed toward said adjoining magnetic pole from said one magnetic pole, and two or more bridges, other descriptions said rotator It is the configuration which has said magnetic pole core which consists of the magnetic substance focusing on a magnetic pole, and connected the opening side of said bridge and said magnetic pole core by the part of said periphery bridge. It is in the point which the radial width of face S1 and S2 of said periphery bridge and S3 .... are larger than Maximum Sm, and carried out hoop direction width of face St by the side of the opening of said magnetic pole core.
[0008] Furthermore, said rotator has another description in the place which has two or more slits formed

toward said adjoining magnetic pole from said one magnetic pole, and made the configuration of this slit unsymmetrical to the hand of cut.
[0009] the configuration which according to this invention prepares two or more slits which go to the next magnetic pole from one magnetic pole of a rotator, and is large and makes width of face of a bridge small by the anti-opening side by the opening side -- the ratio of the reluctance based on magnetic poles (Xd), and the reluctance between magnetic poles (Xq) -- it is large in Xd/Xq, that is, generating torque can be enlarged.
[0010] Moreover, by [of the radial width of face S1 and S2 of a periphery bridge, and S3 --] making maximum larger than Sm, mechanical reinforcement can be enlarged and hoop direction width of face St by the side of the opening of a magnetic pole core can be made into the structure of being equal to high-speed rotation.
[0011] Furthermore, it is Xd/Xq much more by preparing two or more slits (nonmagnetic section) which go to the next magnetic pole from one magnetic pole of a rotator, and making a slit configuration unsymmetrical in a hand of cut. Enlarging is possible.
[0012] A small lightweight and efficient reluctance motor can be offered by the above. Moreover, by carrying these as a drive motor of an electric car, since it can be equal to high-speed rotation, a motor can be miniaturized, and 1 charge mileage can be lengthened. Moreover, since torque is large, an electric car with the sufficient acceleration engine performance can be offered.
[0013]
[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing. Drawing 1 is drawing showing the important section cross section of the reluctance motor of one example by this invention. The A-A cross section of drawing 3 is shown. Drawing 2 is the partial enlarged drawing of the rotator of the reluctance motor of drawing 1 . Drawing 3 is the fragmentary sectional view showing the whole reluctance motor of drawing 1 . It explains to coincidence with reference to drawing 1 - drawing 3 . Here, one example in the coil structure of a distributed winding is explained as a stator. In drawing, a reluctance motor 1 is constituted including a stator 2, a rotator 3, and an end bracket 9.
[0014] A stator 2 is constituted including a stator core 4 and a stator winding 5. Here, a stator core 4 consists of circular ring-like York 41 and an iron core tooth part 42, and the slot 43 which contains a stator winding 5 is established between the iron core tooth part and the iron core tooth part. On the other hand, a rotator 3 is constituted including the rotor core 7 and shaft 8 which consist of the magnetic substance, such as silicon steel. And the rotor core 7 is making the configuration which has the slit 72 of two or more concentric circle arc configurations to the hoop direction, and a bridge 74 is arranged like a slit 72 between slits 72 at a concentric circle arc. Here, The bridge 74 is connected like illustration (drawing 2) of the periphery section with the periphery bridge 71.
[0015] That is, the centrifugal force of a rotator is borne and it has structure which a rotor core does not separate scatteringly on each bridge.
[0016] In addition, generally the interior of a slit 72 is a cavity, and is filled with the air which is nonmagnetic material. Moreover, it is good even if it fills up the interior of a slit 72 with nonmagnetic material, such as a varnish and synthetic resin, nonmagnetic electric conduction material like aluminum, etc.

[0017] As shown in drawing 2 , the periphery section of a rotor core 7 consists of a periphery bridge 71, and a slit 72 (72a, 72b, 72c, 72d, 72e) and a bridge 74 (74a, 74b, 74c), the periphery bridge 71 and a bridge 74 form a magnetic path, and the part of a slit 72 serves as a non-magnetic path. This slit 72 is also called a nonmagnetic slit. On the other hand, the magnetic pole core (or salient pole core) of a rotor core 7 is the magnetic pole core 73 which consists of the magnetic substance, and is a configuration which forms the magnetic path and the load member.
[0018] In drawing 2 , each Bridges [74a, 74b, 74c, and 74d] width method is set to t1, t2, t3, and t4, using the width method of the periphery bridge 71 as s. Moreover, each width method of Slits 72a, 72b, 72c, 72d, and 72e is set to d1, d2, d3, d4, and d5. However, d5 is taken as average width of face.
[0019] And d1<d2<d3<d4 Or it is made the relation of d1<d2<d3<d4<d5. That is, toward the opening side (air gap side of a periphery) of a rotator 3, it is large and the width method of the slits 72a, 72b, 72c, 72d, and 72e as a nonmagnetic slit is made small toward the anti-opening side (main anti-air gap side) of a rotator 3. In addition, it is from the point of efficient-izing which is the purpose of this invention although it is the relation of t1=t2=t3=t4>s (or t1=t2=t3=t4<=s) the case of this example, The above-mentioned relation does not adhere to each width method of each bridge so that it may mention later. Moreover, the width of face d5 of slit 72e of the outermost periphery shall be chosen as arbitration.
[0020] On the other hand, a rotator 3 is a configuration held pivotable at the bearing 10 fitted in the end

bracket 9 through the shaft 8 fitted in the rotor core 7. Here, although the configuration which does not have a frame in the periphery of a stator core 4 showed, a frame may be used depending on the need. On the shaft 8 of a rotator 3, it has the magnetic pole position transducer PS which detects the location of a rotator 3, and the position transducer E.
[0021] Here, W1+, W1-, W2+, and W2- are connected to V1+, V1-, V2+, V2-, and W phase at U phase of a stator winding 5 at U1+, U1-, U2+, U2-, and V phase, respectively. In addition, as for a stator winding number, +, and -, 1 of a subscript shows the direction of a volume of a stator winding 5. Moreover, in the case of this example, the example of four poles is shown.
[0022] As shown in drawing 1 , the description of the reluctance motor of this example prepares at a rotator two or more nonmagnetic slits which go to the next magnetic pole from one magnetic pole (or salient pole) of the rotator concerned, and is in the place which is large and makes the width method of the nonmagnetic slit small toward the core side (anti-air gap side) of a rotator toward the periphery side (air gap side) of a rotator. An air gap is the opening of the rotator periphery formed between the stators which the rotator to rotate is fixing. Moreover, the magnetic reluctance of a rotator of the magnetic pole core 73 is magnetically small by existence of a slit 72, the magnetic reluctance between magnetic pole cores becomes large, and will show the so-called magnetic polarity, and the core of a magnetic pole becomes the magnetic pole core 73. In this invention, it is characterized by considering as the configuration which prepares two or more slits which go to an adjoining magnetic pole from one magnetic pole to the slit configuration of the equal width of face of the conventional example, and is large and makes width of face of the slit section small by the anti-opening side by the opening side. By this, it considers as the configuration which brings near a bridge 74 by the magnetic pole core side.
[0023] Next, the principle of the reluctance motor of this invention is explained. Drawing 4 is drawing showing the principle of the reluctance motor by this invention. The example which developed the circular rotator 2 at the flat surface to the hoop direction shows this drawing. The opening flux density distribution at the time of applying the stator winding magnetomotive force of each stator winding 5 to drawing 4 (b) in the Xq direction is shown in the Xd direction at drawing 4 (a). Here, the Xd direction has pointed out the middle direction of magnetic pole core 73 comrades (the direction of [between magnetic poles]) where the direction of a core of the magnetic pole core 73 (the direction of a magnetic pole core) and the Xq direction adjoin.
[0024] Generally, the torque T of a reluctance motor is proportional to the ratio of the reluctance Xd generated in the direction of the magnetic pole core when applying stator winding magnetomotive force in the Xd direction, and the reluctance Xd between the magnetic poles when applying stator winding magnetomotive force in the Xq direction which carries out direction generating, and Xd/Xq.
[0025]
T** (Xd/Xq) (several 1) Reluctance Xd and Xq is proportional to the inductance Ld when applying stator winding magnetomotive force in the Xd direction, respectively, and the inductance Lq when applying stator winding magnetomotive force in the Xq direction again. Therefore, torque is proportional to Ld/Lq.
[0026] Generally, an inductance L (Ld and Lq) is expressed with a degree type. L=Nand** / Ia (several 2) Here N: -- number-of-turns **: of a stator winding -- the magnetic-flux Ia:stator winding current (several 2) type shows making an inductance L increase by making generating magnetic-flux ** increase to the current of a stator winding 5. And it is important to set with a reluctance motor generally and to enlarge the ratio of the reluctance based on magnetic poles (Xd) and the reluctance between magnetic poles (Xq) and Xd/Xq.
[0027] For convenience, in drawing 4 (a), the effect of the bridge (periphery bridge 71) of the periphery section is disregarded, The opening flux density distribution at the time of setting the permeability of a slit (slits 72a, 72b, 72c, 72d, and 72e) to 0 (zero) was shown. Therefore, it is assumed that the flux density of the periphery bridge 71 is zero, and magnetic flux passes along it only to a bridge 74 in this case.
[0028] As shown in drawing 4 (a), rather than it arranges slits [of the conventional method / 72a, 72b, 72c and 72d] width of face by the same size method clearly in the direction of X Like the method of this invention, The direction which made Slits [72a, 72b, 72c, and 72d] width of face it is large and small by the opening side at an anti-opening side A bridge 74 will approach magnetic pole core side, If the part of "the magnetic path which the bridge 74 which is the magnetic substance of a rotator forms" located in the one where stator winding magnetomotive force is larger increases and it puts in another way Since a bridge 74 moves to a magnetic pole core side as compared with the former and also increases the amount of generating magnetic flux by it, the whole amount of magnetic flux increases.
[0029] By the increment in this amount of magnetic flux, the reactance and inductance of the Xd direction as a reluctance motor increase. On the other hand, about the Xq direction, it acts reversely [above-

mentioned] and the reactance and inductance of the Xq direction of this invention decrease to the conventional method. [of a method] the ratio which is the index of the torque characteristic of a reluctance motor by this -- as compared with the conventional method, the direction of the method of this invention is improved and Xd/Xq and Ld/Lq can be used as an efficient small lightweight reluctance motor.
[0030] Drawing 5 (a) is drawing showing the important section cross section of the reluctance motor of other examples by this invention. Here, the same sign as drawing 1 shall show the same configuration. Drawing 5 (b) is drawing showing the important section enlarged drawing. The description of the reluctance motor of this example is for structure to become firm and for it be suitable for high-speed rotation. That is, since there is a possibility that the mechanical reinforcement of a rotator may fall and the advantage of an original reluctance motor will be lost although an electric property improvement can be made if a slit 72 is formed as the example of this invention showed, the improvement of the mechanical reinforcement of a reluctance motor which has this slit 72 is aimed at. It constitutes from this example more greatly than the width of face of the magnetic pole periphery section in which the nonmagnetic slit section of a slit 72 or a bridge 74 excluding the magnetic pole core 73 in the width of face of the magnetic circuit of the magnetic pole core 73 which constitutes the magnetic pole core of a reluctance motor 1 was formed.
[0031] In drawing 5 (b), the width of face of the periphery bridge 71 located in the periphery edge of a slit 72 shall be expressed with S1, S2, S3, S4, and S5 like illustration according to the location of each slit 72. Here, these S1, S2 and S3, S4, and the maximum of S5 are defined as Sm. And when hoop direction width of face of the magnetic pole core 73 is set to St, in this invention, it is characterized by considering as St>Sm.
[0032] Thus, the mechanical reinforcement of a rotator 3 is securable, improving an electric property by the principle explained by drawing 4 by making large hoop direction width of face St of the magnetic pole core 73.
[0033] that is, gradually, size, it attributes, stress is told to the magnetic pole core 73 side, and the reinforcement as the whole bridge is raised for the width of face of the periphery [as for which the centrifugal force concerning the bridge 74 located between magnetic poles by considering as the configuration as for which the die-length dimension of the bridge 74 of a radii configuration becomes gradually large becomes gradually large] bridge 71 which is alike and follows and receives the centrifugal force concerned. By the above configuration, the mechanical reinforcement to high-speed rotation can be secured, and a small lightweight reluctance motor can be offered.
[0034] Drawing 6 is drawing showing the important section cross section of the reluctance motor of another example by this invention. Here, the same sign as drawing 1 shall show the same configuration. In order to decrease the reactance of d shaft in this example It is the structure which moved some periphery bridges 71 which suited the periphery side (the outermost periphery) of a rotator 3 to the core side (inside) of a rotator 3 as shown in drawing 6 ., Specifically, the periphery bridges 71b and 71d corresponding to slit 72b and slit 72d are moving to the inside part from outermost periphery grade.
[0035] Since the magnetic flux generated with the magnetomotive force of the stator winding 5 of q shaft needs to pass through the periphery bridges 71b and 71d by this It becomes a magnetic path with a long overall length like a maze, and magnetic reluctance becomes large., It is connected with this reducing the amount of generating magnetic flux, making the reactance of q shaft decrease, and raising the property as a reluctance motor.
[0036] Drawing 7 is drawing showing the important section cross section of the reluctance motor of example with one [another] more by this invention. Here, the same sign as drawing 1 shall show the same configuration. In a reluctance motor, in order to minimize torque/current, it can attain by applying the coil magnetomotive force of a stator winding 5 to the location to which it went about 45 degrees from the magnetic pole magnetic pole core. Therefore, flux density distribution of the opening section serves as max in the location to which it went 45 degrees from the magnetic pole core. Although slit width is almost the same in the example shown in drawing 1 - drawing 6 It doubles with the above-mentioned property of "becoming max in the location to which it went 45 degrees from the magnetic pole core", in the example in drawing 7 , It is characterized by to make smaller than the slit T2 of the location which was late for the hand of cut like illustration width of face T1 of the slit 72 of the location which went to the hand of cut from the magnetic pole core., If it puts in another way, a rotator will have two or more slits formed toward the adjoining magnetic pole from one magnetic pole, and will make the configuration of this slit unsymmetrical to a hand of cut. For example, it is small in the width of face of the hand of cut of a slit, and width of face of an anti-hand of cut is enlarged, and suppose that it is unsymmetrical. It can be made an efficient configuration by changing the rate of occupying by the above configuration to the slit 72 of the width of

face of the bridge 74 which forms a magnetic path. In addition, although the above-mentioned example showed the configuration which changes the width of face of a slit 72, the purpose can be attained also by changing the width of face of a bridge 74.

[0037] Further, It sets to the reluctance motor of the example in drawing 7 , and is slit 72a by the side of a midst alignment (most-inner-circumference section). Or the configuration which inserts a permanent magnet 6 in the interior of nearby slit 72b is shown. The magnetic flux generated on q shaft can be controlled effectively, pressing down the increment in the centrifugal force by the permanent magnet 6 in slit 72a to the minimum, if it is this configuration. Furthermore, if the reinforcement of a permanent magnet 6 is strong, the magnetic flux by the permanent magnet 6 produces positive torque generating, and can use it as a small lightweight dynamo-electric machine. On the other hand, the magnetic flux generated on q shaft in the minimum amount of magnets can also be controlled by putting a permanent magnet 6 into slit 72e by the side of the outermost periphery (the outermost periphery), or slit 72d of near.

[0038] On the other hand, the cross section of a permanent magnet 6 can be made large by inserting a permanent magnet 6 in the slit 72 by the side of inner circumference. This can enlarge magnetic flux of a permanent magnet and can make generating torque increase. In addition, effectiveness of reducing magnetic flux (it acting as a brake to motor torque with d shaft) with raising a motor property and generating big torque if a permanent magnet 6 is inserted in the slit 72 in drawing, and q shaft by permanent magnet magnetic flux, And it is because big generating torque is acquired according to the effectiveness of both which generate torque positively by the magnetic flux by the permanent magnet. In addition, it is needless to say that the above-mentioned permanent magnet may be inserted in which part of a slit 72.

[0039] In each above example, although the reluctance motor of distributed-winding structure was explained, it is applicable with the reluctance motor of concentrated-winding structure. Moreover, not only a motor but a generator may be used, and it can apply also to an abduction mold and the lilac KUTANSHI motor using an introvert mold rotator. Moreover, the application to a linear motor etc. is also possible only to a dynamo-electric machine.

[0040]

[Effect of the Invention] According to this invention, the electric car equipped with lightweight and efficient a small reluctance motor and small it can be offered.

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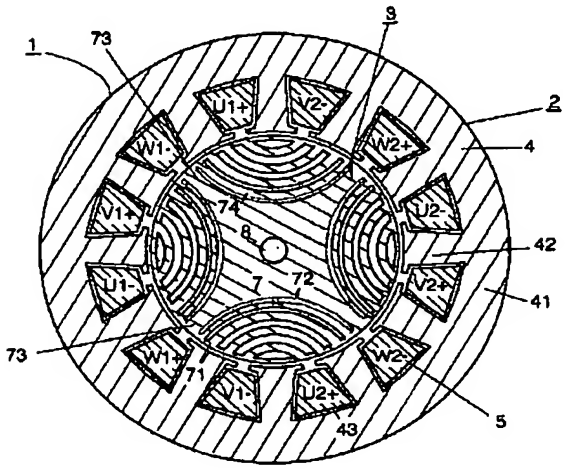
DRAWINGS

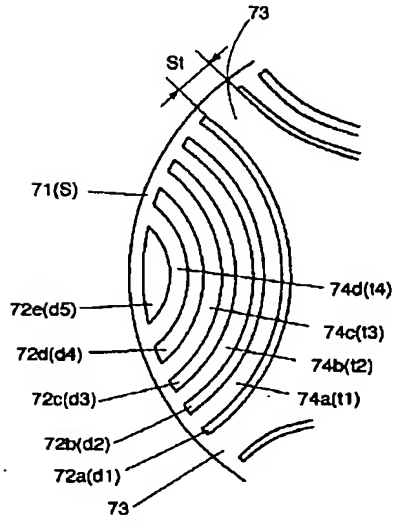
[Drawing 1]

図1



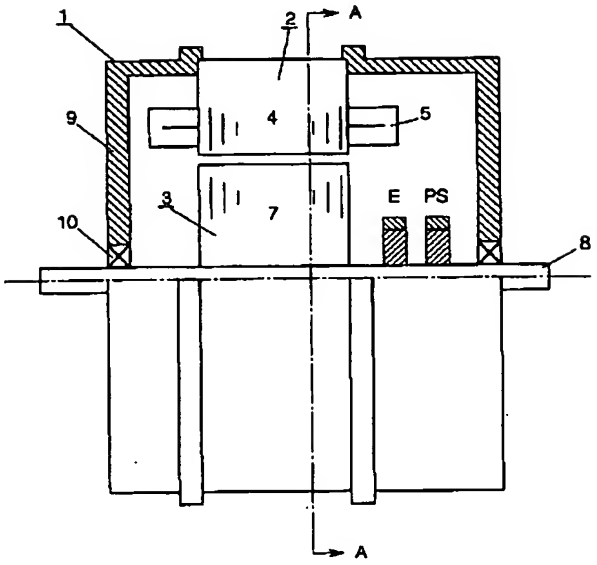
[Drawing 2]

図2



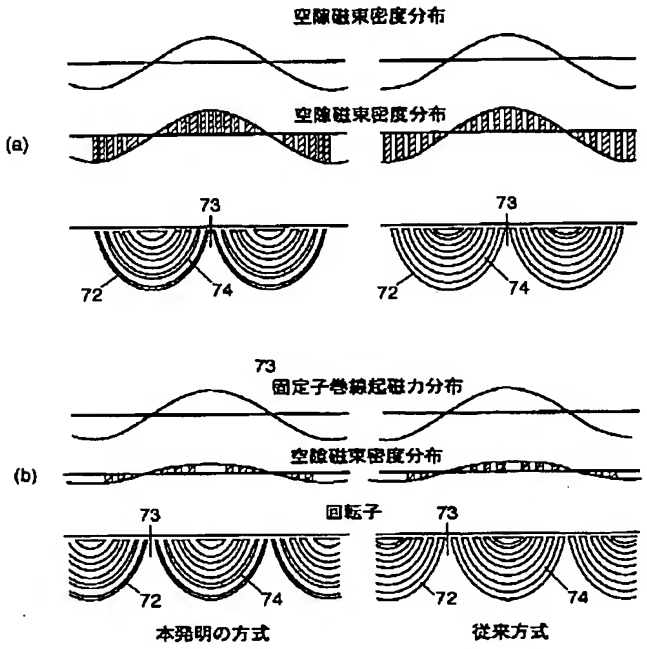
[Drawing 3]

図3



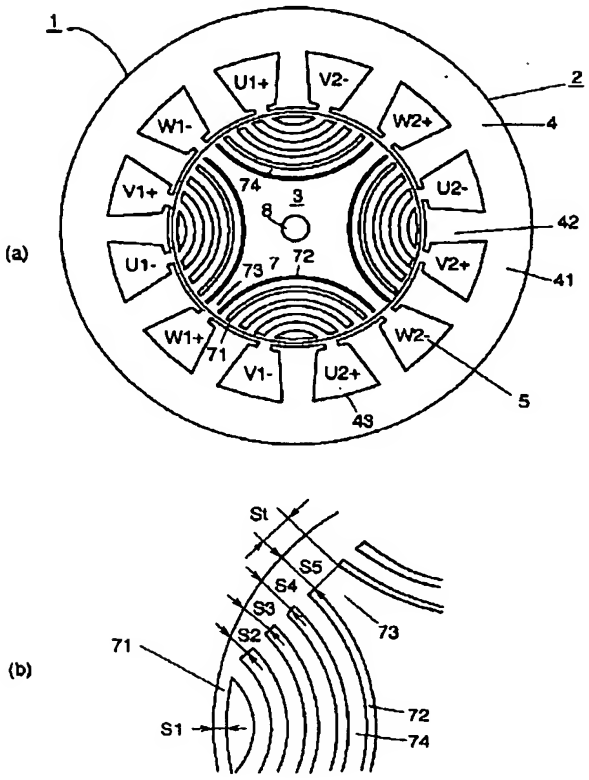
[Drawing 4]

図4



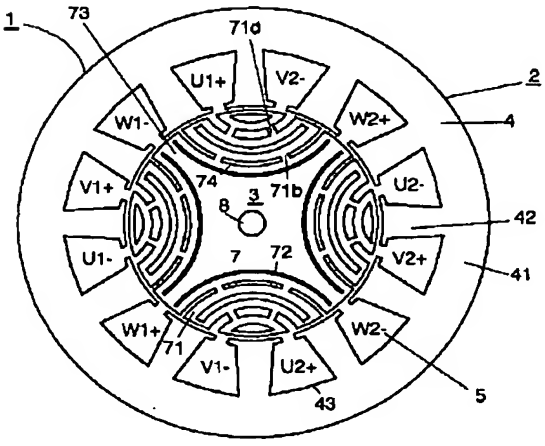
[Drawing 5]

図5



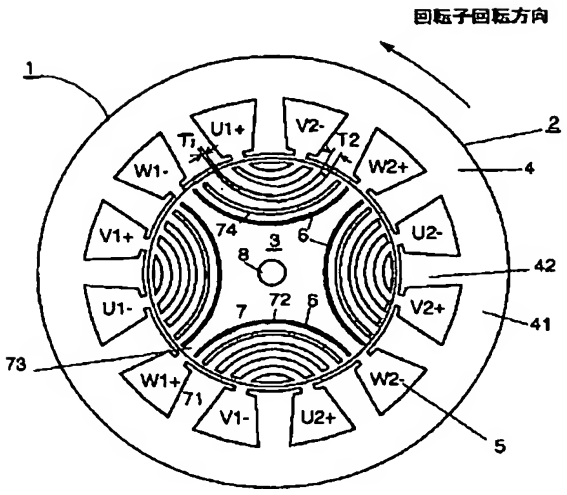
[Drawing 6]

図6



[Drawing 7]

図7



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